the SMA member **22**—drives the driven component **16**. Furthermore, each of the pulley members may be connected to the driven component **16**, or may feed into a transmission or gear system before transferring mechanical energy to the driven member **16**. Although three rotational members are shown in FIG. **2**, it should be appreciated that more or fewer members may be used.

[0069] As described herein, the SMA member **22** may be embedded within a belt or cable. Furthermore, the SMA member **22** may be configured as a longitudinally extending wire that is embedded within the belt such that the belt longitudinally expands and contracts as a function of the associated SMA member **22** as it is expanding and contracting. Additionally, or alternatively, the SMA member **22** may be configured as one or more helical springs that may be embedded within the belt. The SMA member **22** may be a wire that has any desired cross-sectional shape, i.e., round, rectangular, octagonal, ribbon, or any other shape known to those skilled in the art; and the term wire may refer to SMA of any shape. Additionally, the belt may be at least partially formed from a resilient material. For example, the resilient material may be an elastomer, a polymer, combinations thereof, and the like. The belt may be formed as a continuous loop, as shown in FIGS. **2** and **3**, or as an elongated strip, which is then joined at its ends to form a loop.

[0070] SMA wire can also be flattened into ribbons of arbitrary aspect ratios. Ribbons have better lateral heat transfer characteristics than wire of the same cross-sectional area. When wound around a flat pulley, ribbons have higher friction than straight wire, due to the added contact area. While high aspect-ratio ribbons may have fatigue problems, ribbon with a 3:1 cross-sectional aspect ratio has similar fatigue properties to that of straight wire. However, ribbon having a 3:1 cross-sectional aspect ratio may increases heat transfer by twenty percent. Ribbon-type SMA working members may be, for example and without limitation: straight, wavy or corrugated, with cutouts or holes, or with hanging chads (active or nonactive).

[0071] In operation of the heat engine **14** shown in FIG. **2**, a localized region of the SMA member **22** may be disposed within, or directly adjacent to, the hot region **18** such that the first temperature causes that corresponding localized region of the SMA member **22** to longitudinally contract as a function of the first temperature of the hot region **18**. Similarly, another localized region of the SMA member **22** may be similarly disposed within, or adjacent to, the cold region **20** such that the second temperature causes that localized region of the SMA member **22** to longitudinally expand as a function of the second temperature of the cold region **20**.

[0072] For example, if the first temperature of the hot region **18** is at or above the hot state, the associated localized region of the SMA member **22** will longitudinally contract as a result of a phase change of the SMA member **22** from the martensite phase to the austenite phase. Similarly, if the second temperature of the cold region **20** is below the cold state, the associated localized region of the SMA member **22** will longitudinally expand as a result of a phase change of the SMA member **22** from the austenite phase to the martensite phase.

[0073] The SMA member **22** is continuously looped about the first pulley **38** and the second pulley **40** such that motion imparted from the SMA member **22** causes rotation of each of the first pulley **38** and the second pulley **40** (and also the idler pulley **42**). The longitudinal expansion and/or contraction of the localized regions of the SMA member **22** impart motion from the SMA member **22** to the first pulley **38** and the second pulley **40** to move or drive the driven component **16**. The localized regions are those portions of the SMA member **22** that are in the respective hot region **18** and the cold region **20** at any given moment.

[0074] As shown in the heat engine **14** of FIG. **2**, when the SMA member **22** contracts after being heated by the hot region **18**, the first timing pulley **39** provides a larger reactive torque than the second timing pulley **41**. Therefore, the contraction of the SMA member **22** between the first pulley **38** and the second pulley **40** (which rotate in common with the first timing pulley **39** and the second timing pulley **41**, respectively) causes the SMA member **22** to move toward the first pulley **38**. As the heat engine **14** enters dynamic operation, the SMA member **22**, the first pulley **38**, and the second pulley **40** rotate counterclockwise (as viewed in FIG. **2**).

[0075] The heat engine **14** does not require liquid baths for the hot region **18** and the cold region **20**. Therefore, the heat engine **14** does not require significant portions of the SMA member **22** to be submersed in liquids.

[0076] In a heat engine dominated by bending, such as a thermobile-type heat engine, output can be increased by constructing an I-beam with SMA elements. In the I-beam, the SMA elements are located at the flanges and a non-active material, such as rubber, is located in the web. Similarly, box beams can be constructed from SMA elements. In box beams, the SMA material is moved away from the neutral axis in the bending dominated heat engine. This increases utilization of the SMA, and thus increases the power output capability of the bending type heat engine.

[0077] Referring again to the SMA member **22** of FIG. **2** acting as the SMA working member or working element in the heat engine **14**, different techniques or modifications may be used on the SMA member **22** to improve the efficiency of the heat engine **14**. The surface or surfaces of the SMA member **22** interacting with, in particular, the first pulley **38** and the second pulley **40** may be treated to increase or decrease traction, and to increase or decrease heat transfer to and from the SMA member **22** to the hot and cold regions **18**, **20** or to the pulley members **38**, **40**.

[0078] One treatment of the SMA member **22** is to remove the oxide layer from the SMA member **22** surface. An oxide-free SMA member **22** may result in increased friction between the SMA member **22** and pulleys **38**, **40**, especially when the pulleys are constructed of steel. Removal of oxides may also increase rates of conductive, convective, and radiative heat transfer to and from the SMA member **22**.

[0079] Another treatment for the SMA member **22** may involve roughening the surface of the SMA member **22**. Roughening may increase traction through increased friction, and has been shown to have no measurable detriment to convective heat transfer.

[0080] Coatings may also be added to the SMA member **22**. Coatings on the SMA member **22** will increase surface area and may consequently increase heat transfer rates if the coating has a better transfer rate than the SMA and if bonding to the alloy is sufficient. Coatings may also reduce slippage between the SMA member **22** and the pulleys **38**, **40**. In situations where cooling rates are too high (very low exterior temperatures) coatings could mitigate heat stripping or over-cooling.

[0081] Additional treatments of the SMA member **22** may include, without limitation: welded features and etching.